SMC-TR-98-29

AEROSPACE REPORT NO.
TR-98(8550)-2

Guidelines for the Use of SDCE

1 March 1998

Prepared by

R. HADDAD
Computer Science and Technology Subdivision
Computer Systems Division

Prepared for

SPACE AND MISSILE SYSTEMS CENTER
AIR FORCE MATERIEL COMMAND
2430 E. El Segundo Boulevard
Los Angeles Air Force Base, CA 90245

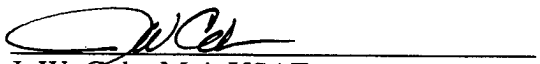
Engineering and Technology Group

THE AEROSPACE CORPORATION
El Segundo, California

This report was submitted by The Aerospace Corporation, El Segundo, CA 90245-4691, under Contract No. F04701-93-C-0094 with the Space and Missile Systems Center, 2430 E. El Segundo Blvd., Suite 6037, Los Angeles AFB, CA 90245-4687. It was reviewed and approved for The Aerospace Corporation by R. R. Razouk, General Manager, Computer Systems Division, Science and Technology Subdivision. Maj J. W. Cole was the project officer for the Mission-Oriented Investigation and Experimentation Program (MOIE) program.

This report has been reviewed by the Public Affairs Office (PAS) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication. Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.



J. W. Cole, Maj. USAF
SMC/AXES

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	1 March 1998	

4. TITLE AND SUBTITLE

Guidelines for the Use of SDCE

5. FUNDING NUMBERS

F04701-93-C-0094

6. AUTHOR(S)

Haddad, Ranwa

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

The Aerospace Corporation
Technology Operations
El Segundo, CA 90245-4691

8. PERFORMING ORGANIZATION REPORT NUMBER

TR-98(8550)-2

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Space and Missile Systems Center
Air Force Materiel Command
2430 E. El Segundo Blvd.
Los Angeles Air Force Base, CA 90245

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

SMC-TR-98-29

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

This report summarizes lessons learned collected from 13 SDCE applications that Aerospace participated in between 1993 and 1997, and derives guidelines for optimizing the SDCE process. The guidelines include a simplified tailoring process, revised RFP templates, and a core set of SDCE questions. SDCE was designed to be performed in the context of a source selection; the first version of SDCE was issued by AFMC in 1993, at the beginning of Acquisition Reform. The guidelines provided herein emphasize the integration of SDCE with Acquisition Reformed Source Selections. In addition, the report examines how SDCE can be extended for downselect or post-award software risk assessments.

14. SUBJECT TERMS

Software Development Capability Evaluation (SDCE), Software Evaluations, Software Assessments, Software Risk, Software Acquisition, Capability Evaluation, Software Technology Capability Evaluation

15. NUMBER OF PAGES

50

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

Acknowledgments

Several individuals provided valuable contributions to this document directly or indirectly. The author wishes to thank all of them, with special mention for each of the following people: Lt Col Phillip Gordin, Richard Adams, Justin Biddle, Art Buchwald, Suellen Eslinger, Judy Kerner, Nancy Kern, Carol Ledoux, and Carl Miller for contributing their lessons learned; Andy Guillen, Al Hoheb for their help interpreting the current acquisition regulations and analyzing their relation to SDCE; Col Alan Kirschbaum, SMC/AXE, and Col Michael Kaye, SMC/AXD, for their guidance in system engineering and acquisition processes; Mr. Leslie Bordelon, SDCE PAT chairman and director of program management SMC/AX, for his support of the SDCE MOIE and of Aerospace's role in SDCE applications at SMC; and Mr. Phil Babel, AFMC OPR for SDCE, for the advice and support he provided to several of our SDCE applications.

In addition, many thanks go to the publications team who provided valuable editing support under Toni Powell's leadership.

Contents

Figures

1. Introduction

The purpose of this report is to consolidate lessons learned collected from 13 SDCE applications between 1993 and 1997, and synthesize a small set of guidelines for SDCE use. The SDCE methodology is described in full detail in AFMC Pamphlet 63-103 "Software Development Capability Evaluation" [ref 1], however, the description of SDCE in the AFMC pamphlet allows many choices in certain areas. The choices in the original SDCE documentation were there partly by design, to support tailorability of the method. As a result, we observed variances in the way SDCE was applied from one program to the other, we monitored these variances, we tracked the SPO's satisfaction with respect to the choices made for the variances after their SDCE application was completed, and we used this feedback to derive the guidelines contained in this document.

The guidelines below were arrived at through a systematic collection of metrics and lessons learned, and quantitative and qualitative analyses of the collected data. This analysis was performed in the context of the SDCE Metrics Mission Oriented Investigation and Experimentation (MOIE) project. In general, the metrics indicate that SDCE has been an effective tool for discriminating among bidders and predicting software risk in a source selection. Furthermore, most SDCE applications tracked received high ratings for user satisfaction. The guidelines contained in this document are aimed at eliminating occurrences that resulted in low user satisfaction, and at optimizing future SDCE applications.

One of the features that distinguishes SDCE from other software evaluation methods is the fact that the evaluation is integrated with the overall acquisition process. Therefore a key requirement to a successful SDCE application is to understand the system acquisition framework in which SDCE is performed, and the relationships between the SDCE activities and the system acquisition activities. Chapter 2 provides an overview of the SDCE, as a reference. Chapter 3 describes the system acquisition process and the SDCE process, and relates the two.

Another feature that distinguishes SDCE from other software evaluation methods is the fact that it is highly tailorable to the needs of each acquisition. Chapter 4 contains a discussion of the variances currently allowed in the SDCE pamphlet, when the choices for each of the variances needs to be made, and what considerations should accompany each of these choices, and reduces the SDCE tailoring process to a sequence of six steps.

Chapter 5 contains a compilation of the lessons learned from the 13 SDCE applications that were tracked, and organizes them with respect to the main activities that constitute the SDCE process as described in chapter 2. Chapter 6 identifies the questions and criteria that were most frequently asked on past SDCEs. These are offered as a baseline for identifying a core subset of SDCE, and can be used as a starting point for SDCE model tailorings.

Chapter 7 discusses the issues associated with performing SDCE outside the source selection framework. Several attempts were made to that effect, with limited success. This chapter explains the motivations behind these attempts, describes the difficulties encountered, and provides recommendations for extending SDCE outside the source selection framework.

Chapter 8 contains a list of recommended modifications and improvements to the current version of AFMC's SDCE pamphlet. These recommendations are based on the guidelines described in previous chapters. As a result, chapter 8 is somewhat redundant with the previous chapters, however, its purpose is to consolidate those lessons learned that amount to modifications to the current version of the AFMC pamphlet.

Appendix A contains sample RFP instructions for SDCE. Appendix B contains modified versions of the SDCE Evaluation Templates Appendices A and B reflect the lessons learned and guidelines provided in chapters 4 and 5. Appendix C lists the past SDCEs from which the guidelines in this document were derived, and appendix D lists the acronyms used.

Throughout the report, the terms "contractor", "offeror" and "bidder" will be used interchangeably, similarly for the terms "results" and "findings".

2. SDCE Background

SDCE is a methodology for assessing, during source selection, contractors' capabilities in software and software-related systems engineering disciplines. The SDCE methodology is based on the assumption that contractors who have identified the software-related processes, plans, tools and technologies they plan to use on an upcoming acquisition, and who have prior experience in using them present a lower risk to the acquisition than those who don't. The methodology is used primarily for the acquisition of software-intensive systems at the Air Force Materiel Command (AFMC) and is applied in the context of a source selection. The SDCE assessment consists of a process whereby the contractors under evaluation provide information about their capabilities in the form of responses to SDCE questions along with support material that demonstrates their commitment to the proposed processes and technologies, and their past experience with them. The contractors' responses are then evaluated using predefined evaluation criteria, and validated by reviewing the support material and performing a site-visit.

The SDCE questions and associated criteria are organized into a structure that is referred to as the SDCE model. The SDCE model was derived from Aeronautical Systems Center (ASC)'s Software Development Capability Capacity Review (SDCCR) [ref 2] and the Software Engineering Institute (SEI)'s Capability Maturity Model (CMM) [ref 3]. It covers a broad range of disciplines and is meant to be tailored for each assessment, based on the characteristics and requirements of the program for which the assessment is performed. Every application of SDCE on a given program requires a tailoring of the SDCE model to the minimal subset of the model that will adequately represent the anticipated risks of that program.

The SDCE evaluation is performed along three dimensions, corresponding to three categories of inputs from the offerors. They are:

1) Responses to SDCE questions describing the processes, plans, tools, methods and technologies proposed for the program. These are evaluated against the SDCE criteria and the technical requirements of the acquisition to ensure their adequacy with respect to the acquisition's technical requirements and programmatics.

2) Documentation of proposed processes, tools and plans in document(s) that are intended to be used in the acquisition at hand, such as Software Development Plans, Coding Standards, etc.

3) Samples from past projects demonstrating the offerors' experience with the proposed processes, tools and technologies.

Note that categories 2) and 3) constitute the support material that accompany the SDCE responses with the proposal. Support material is reviewed to establish a measure of confidence in the offerors' SDCE responses. The support material is usually not page limited.

A given SDCE application entails performing the activities listed in figure 1. This list is provided as a reference for further discussions of SDCE experiences and lessons learned. The sequencing of SDCE activities is illustrated in Figure 2. More details about SDCE can be found in the SDCE AFMC Pamphlet 63-103 "Software Development Capability Evaluation" [ref 1].

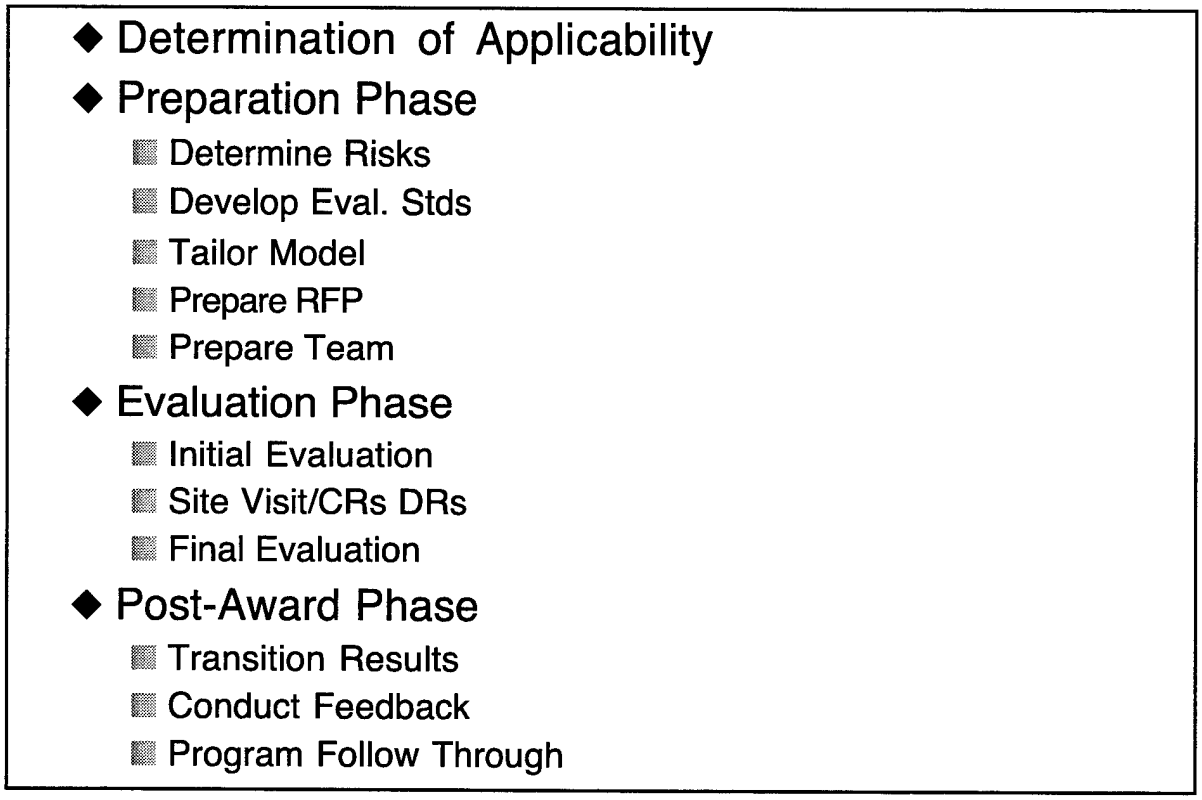


Figure 1. SDCE Activities

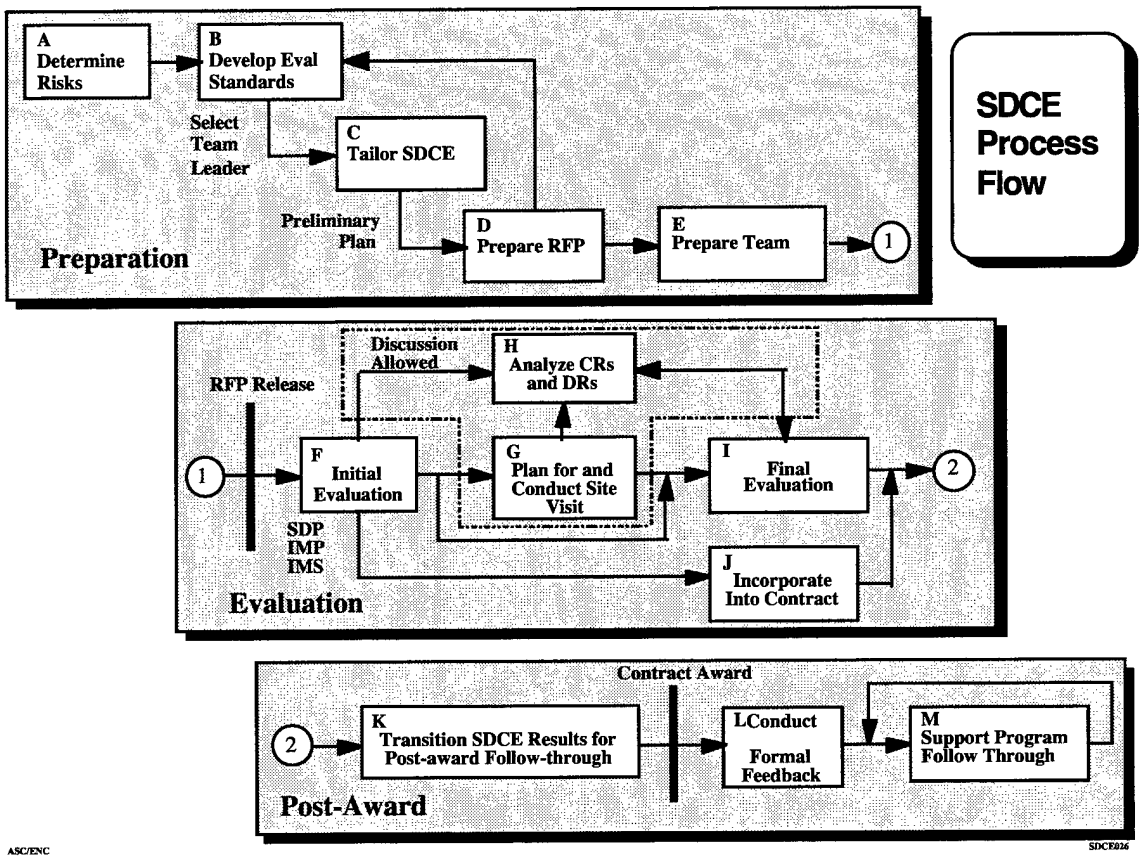


Figure 2. SDCE Process Flow

3. Applying SDCE from a System Acquisition Perspective

3.1 System Acquisition Process

One of SDCE's unique features is its tight coupling to the specific acquisition for which it is performed. As a result, the SDCE process is highly dependent on the overall system acquisition process. The discussion below gives a few details about the system acquisition phases, SDCE activities, and how the two are integrated. A more complete description of the system acquisition process can be found in the Federal Acquisition Regulations (FAR) [ref 4], and the Air Force FAR Supplement (AFFARS) [ref 5].

The system acquisition process can be divided into four main phases: the acquisition strategy planning phase, the RFP preparation phase, the source selection phase, and the post award phase (see figure 3). The acquisition strategy planning phase corresponds to the identification of objectives for the acquisition, the identification of the main risks associated with the acquisition and the development of a strategy for the acquisition. Typical outputs from the acquisition planning phase are a Mission Needs Statement (MNS), User Requirements (ORD)[1], a Single Acquisition Management Plan (SAMP), a Statement of Objectives (SOO), an Acquisition Strategy Panel (ASP) briefing, etc.

The RFP preparation phase corresponds to the development of a technical requirements document, and the development of evaluation factors and criteria for selecting a "source" for the contract. The development of evaluation factors and criteria is a long and iterative process that consists of refining and prioritizing the evaluation criteria, and organizing them into a "source selection structure" (which corresponds to "Areas", "Factors", "Subfactors", etc.). The RFP preparation phase is also when the government decides what material needs to be received from each offeror with respect to each element in the source selection structure, and identifies the kinds of information that each offeror should include in their proposals. The main output of the RFP preparation phase is the RFP.

The source selection phase is when the government evaluates the offerors' proposals, selects a source, and establishes one or several contracts. The results of the proposal evaluation are documented in the form of strengths, weaknesses, and risks at the lowest levels of the evaluation, and rolled up into three sets of ratings: adequacy ratings (also known as "proposal ratings"), which characterize the adequacy of the proposal, and two sets of risk ratings: proposal risk, which characterizes the risk associated with the proposal, and performance risk, which characterizes the risk associated with the offeror's past performance. The source selection phase itself can comprise one or three subphases, depending on whether the government decides to engage in discussions with the offerors, after an initial evaluation of the proposals. If discussions are allowed ("opened"), then a discussion subphase takes place for clarifications to be made to the proposal. The discussions subphase is then followed by a final evaluation subphase. If discussions occur, they are formalized through reports called Clarification Requests (CRs) and Deficiency Reports (DRs), or Engineering Notices (EN). The collection of outputs generated during the evaluation phase is referred to as the source selection results, which are archived at the end of the source selection.

Finally, the post award phase corresponds to all activities that take place after a source has been selected, and a contract is in place. Most of the activities performed by the government after contract award are aimed at maximizing the quality of the delivered products and reducing the risk of cost and schedule overruns.

---

[1] Although initial versions of the MNS and the ORD are usually developed prior to the start of the acquisition to justify its undertaking, some updated version of an MNS and an ORD are usually associated with the outputs of the Acquisition Strategy Planning phase.

Although these four phases are not equal in terms of calendar time allocated to each of them, the fourth one being by far the longest one, they emphasize the early part of an acquisition. This emphasis is consistent with the belief that it is easier to eliminate problems earlier in an acquisition than later. The early portion of an acquisition is also where SDCE activities are concentrated.

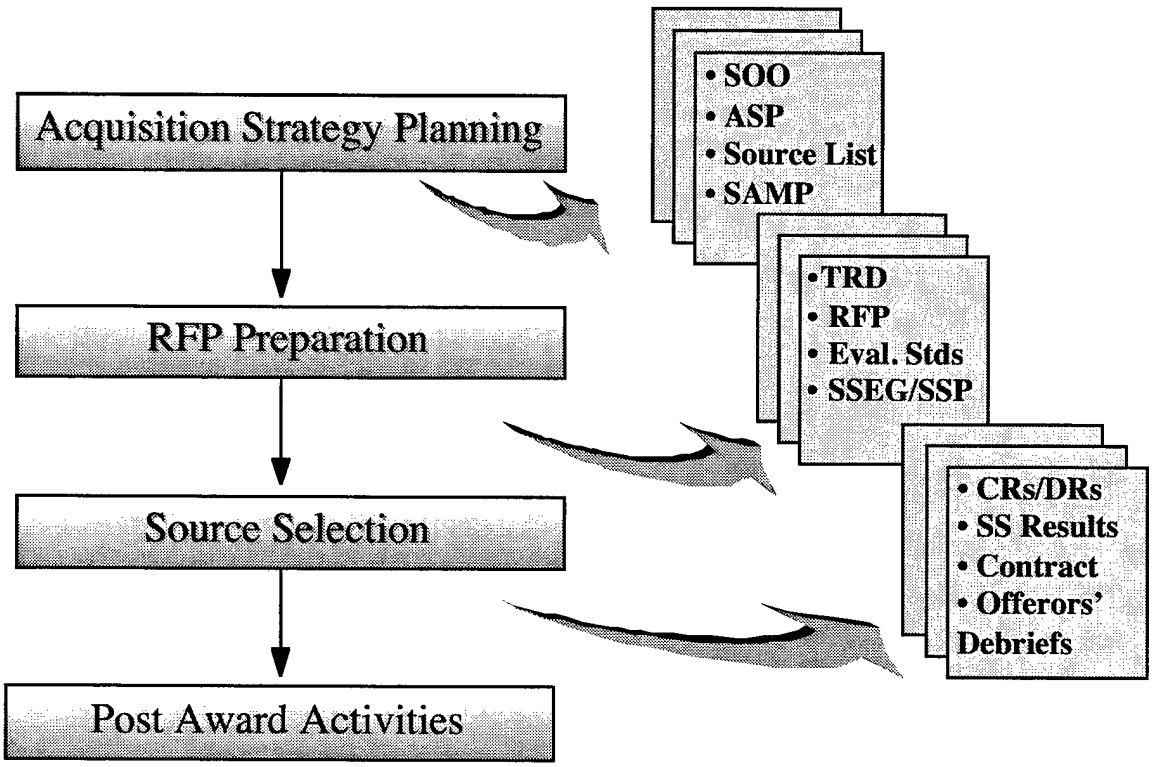


Figure 3. System Acquisition Process

3.2 Relation of System Acquisition Process to SDCE Process

The four phases of SDCE, (1) Determination of SDCE applicability, (2) SDCE preparation, (3) SDCE evaluation, and (4) Post award activities, map directly to the four phases of the system acquisition process described above (see figure 4). In particular, determination of SDCE applicability depends on whether software is considered to be a risk for the acquisition, a determination that should be made during the Acquisition Strategy Planning phase. The Preparation phase includes a determination of SDCE's position in the source selection structure, the development of SDCE evaluation standards, and other activities whose outputs go into the RFP; therefore it should be performed in concert with other RFP preparation activities. Similarly, the evaluation phase of SDCE produces results that feed straight into the source selection, its activities are performed in parallel with other source selection activities, and three out of the four activities in that phase (CR/DR review, Site Visits, and Final Evaluation) are performed only if the source selection authority decides to engage in discussions with the offerors. Finally, the post award activities of an SDCE correspond to a desire by the government to (1) share their risk findings with the offerors (especially the successful ones) and (2) follow up on these risks after the contract has commenced, a desire that applies to software risks and extends to all risks associated with the acquisition at hand.

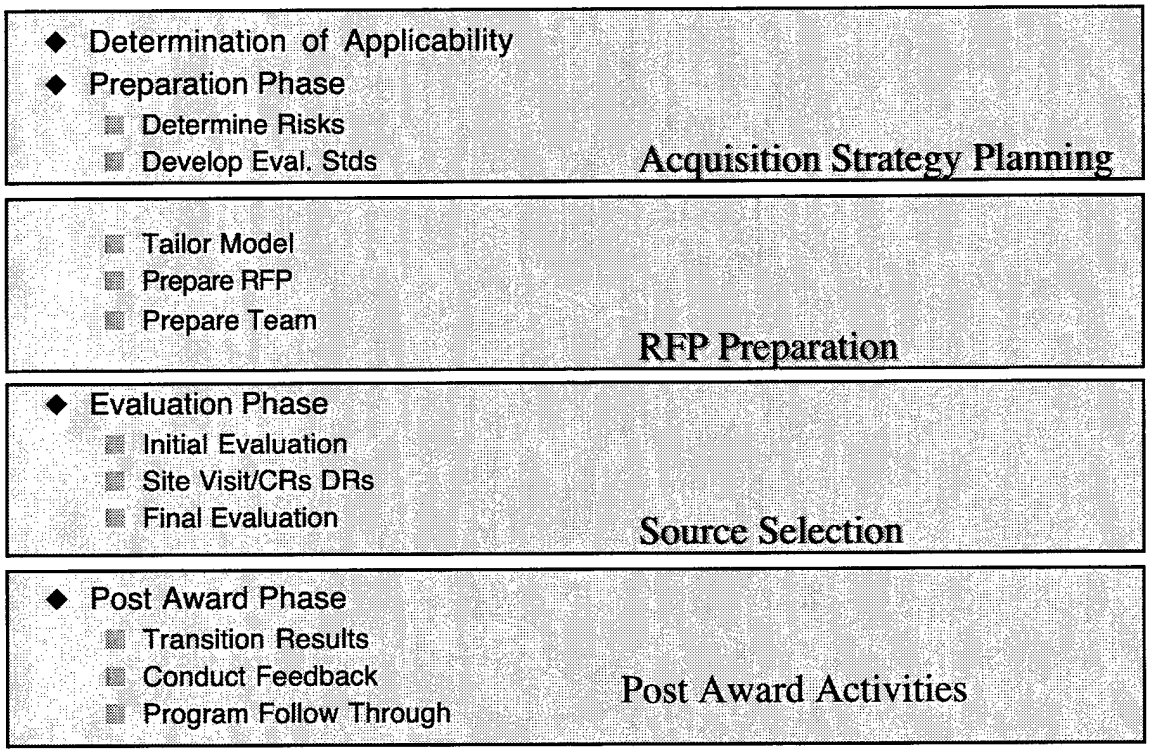


Figure 4. SDCE Within the System Acquisition Process

3.3 Consistency of SDCE with Acquisition Reform

We conclude this chapter with a few remarks about acquisition reform, and how SDCE fits into the reformed acquisition framework.

The main focus of acquisition reform has been to reduce the cost of system acquisitions by reducing or eliminating those government activities that can be performed by the contractors, and by increasing trust in the contractors (Total System Performance Responsbility, reduced contractor oversight, etc.).

SDCE can be viewed as a mitigator for the risk associated with increased trust in contractors. As the government moves away from defining detailed technical requirements, and dictating development processes to the contractors, and as it prepares to select a contractor that it will trust to develop a system with little oversight, it needs increased visibility into the plans, processes, and technologies identified by the contractors for the project at hand and their past record at using these processes and technologies. SDCE provides a structured mechanism for contractors to describe the plans, processes, and technologies identified for the acquisition at hand, along with their past record in them, and for the government to review them and establish their adequacy.

In addition, SDCE facilitates the early identification of program risks, and promotes government-contractor dialogs. SDCE emphasizes risk management in that the purpose of an SDCE is to identify and manage software risks early in the acquisition process; furthermore, the SDCE tailoring is driven by the risks associated with the acquisition at hand. SDCE encourages open dialog with the contractors, and includes activities to that effect at three points: during the planning phases, when SDCE is briefed to the prospective contractors as part of the bidders' conference; during the evaluation phase, the site visit is meant to not only obtain detailed information about the contractors' plans and processes, but also foster cooperation between the government and the contractors; finally, at the conclusion of the evaluation, when debriefs are held to communicate SDCE results to each of the offerors and solicit their feedback.

4. SDCE Tailoring Decisions

The SDCE process can be tailored to accommodate the needs of each acquisition, in terms of resources and schedule. There are a certain number of points during that process where the decisions made have a great effect on the impact of SDCE and the resources required to perform it. These decision points amount to the tailoring process. They are listed in this chapter along with the dependencies between them.

4.1 Primary Tailoring Decisions

The SDCE tailoring process can be summarized by a "how" question and a "what" question, namely:

- How is SDCE going to count in the source selection?
- What software risk areas are most applicable to the acquisition, and therefore should be covered by SDCE?

These two questions can map into six variances in the SDCE process, the values of which need to be planned out carefully. These tailoring decisions are:

1. the position of SDCE in the source selection structure,
2. the total number of questions selected for the evaluation,
3. the selection of SDCE questions,
4. the selection of SDCE team members,
5. the levels at which SDCE results need to be generated,
6. and the decision to perform a site visit.

The following paragraphs explain the significance of the primary tailoring decisions and provide recommendations for how and when to make them.

- Position of SDCE in the Source Selection Structure. The position of SDCE in the source selection structure amounts to deciding how high or low in the structure SDCE is positioned, and whether to keep SDCE as one entity or distribute it among different entities. SDCE position in the source selection structure has varied greatly in the 13 SDCEs tracked. Almost every possibility was tried out; this provided us with many data points and lessons learned that form the basis of the following recommendations. The decision of where in the source selection structure SDCE should be placed should be made early on in the SDCE preparation phase, because the scope of the tailored model should be consistent with the importance of SDCE in the source selection, which in turn is determined by its position in the source selection structure. For example, the selection of a large number of SDCE questions requires a large team to evaluate the offerors' responses to the questions, and consumes equally large resources on the offerors' side, therefore it should not correspond to an SDCE that has a low position in the source selection structure. The optimal placement of SDCE has been as a separate factor under the technical area.

  There were three cases among the tracked SDCEs where SDCE was distributed among different areas and/or factors. The reason why SDCE was distributed is to deconflict it from other related areas and factors. In all cases, this resulted in great difficulties during the evaluation phase, as it was very hard to coordinate the different components of SDCE. Furthermore, the overall impact of SDCE on the source selection was greatly

diminished by its being distributed. Therefore our recommendation is that SDCE not be distributed among different components of the source selection. Further guidance on how to deconflict SDCE from other portions of the RFP is provided in section 5.2.

- Selection of SDCE Questions. The selection of SDCE questions amounts to two types of decisions: the number of questions selected (i.e., the size of the SDCE model), and the choice of questions. The total number of SDCE questions selected on the tracked SDCE applications ranged from 27 to 118. Our recommendation is that the total number be proportional to the importance of SDCE in the source selection, and its place in the source selection structure. The main reason why these numbers are given is to share the fact that several SDCE applications were conducted successfully with a small number of questions selected (between 30 and 50 questions). Observations from past SDCE applications indicate that the more people are involved in the selection of SDCE questions, the larger the number of questions selected; this is probably due to the fact that each person insists on having their "pet" questions included in the selected set. The choice of questions should be based entirely on the risks associated with the acquisition, and not on personal preferences. Further guidance for deciding which questions to select is provided in chapter 5.
- Selection of SDCE Team Members. SDCE team members can be thought of as being in two groups: the group of people who perform the planning and tailoring, and the group of people who perform the actual evaluations. The reason for splitting the team into the two subteams is that the selection of SDCE evaluators may not be feasible early on, because many of them (if not all) have to be able to make a full-time commitment to the source selection for the duration of the initial proposal evaluation, yet the schedule of the proposal evaluation is not determined until the RFP is released, and the date of the RFP release changes a lot as the acquisition progresses. Another difficulty with selecting the SDCE evaluators in advance is that they cannot have any conflict of interest with any of the bidding offerors, yet, in many cases, the offerors are not known with certainty until the proposals are received. So, even though the AFMC pamphlet shows the selection of SDCE team members as one of the early activities in the planning phase, experience has shown that it is not always feasible to make that selection too much in advance of proposal receipt. It is therefore recommended that only one or two members of the team be selected early on (a planning subteam) to work on the tailoring, RFP preparation and other planning activities. Names can be identified for the rest of the team (the evaluation subteam), with backups, but their selection cannot be finalized until the schedule for proposal receipt is firmed up, which is usually only after the RFP is released. Even after the RFP is released, some of the team members identified for the evaluation of SDCE responses may end up disqualified for conflict of interest reasons, therefore it is prudent to have a few extra evaluators lined up for backup.
- Levels at Which SDCE Results are Developed. Because the SDCE model is structured into 5 layers, with the questions and criteria constituting the bottom layer, there are several options for the level at which the atomic results should be generated, and how many levels they should be rolled up to. There are basically two options for the level at which atomic SDCE results are generated: the question/criteria level, or the CC level. The question/criteria level is hard to use because the results can then either be developed on a question-by-question basis or on a criterion-by-criterion basis. However, some questions correspond to several criteria, and some criteria map to several questions, therefore it is easier to document the results for an entire CC at once. As far as the roll-up is concerned, the AFMC pamphlet provides templates for documenting SDCE results at each level of the SDCE model, i.e., at the Critical Capability, at the Critical Capability Area, at the Functional Area, and finally at the overall SDCE level (no templates are provided for developing results at the question and criteria level). Experience has shown that rolling SDCE results from one level of the model to the next offers no benefit; in fact it tends to dilute the significance of the atomic results. It is recommended that the atomic

results be developed at the CC level, and that the only roll-up performed be at the overall SDCE level. This model was successfully used on the past two SDCE applications.

- Decision to Perform a Site Visit. The SDCE process includes a step where site visits are performed in order to corroborate the responses provided by the offerors and to obtain additional clarifications. Site visits, however, are optional; they can be conducted only if discussions are allowed and the schedule of the source selection permits it. Site visits are very useful because they facilitate the insight needed into the offeror's processes, and they promote dialog between the offerors and the government. Unfortunately, they are often impractical to perform, especially when there are numerous offerors who are located in different parts of the country. The problem is exacerbated by the fact that the site visits have to take place during discussions, and discussions are often held during a short period of time (two weeks). It is recommended, however, that site visits not be precluded. The bidders should be prepared to host site visits, and the final decision to hold them should be made after the proposals are received and the preliminary evaluation is completed.

4.2 Dependencies Between the SDCE Tailoring Decisions

SDCE activities are tied to other source selection activities, and those in turn are performed in a highly iterative fashion, therefore it may not be possible to control the sequencing of SDCE activities completely. Care should be taken, however, to understand the dependencies between the different tailoring decisions and ensure that any changes made during the RFP preparation phase to any of them preserves the consistency of the overall SDCE tailoring. Again the main example is when the position of SDCE changes by reducing its importance, the size of the tailored model should be reduced. We have often observed the reverse, i.e., situations where, as time goes by during the RFP planning phases, the tailored SDCE model expands while the position of SDCE in the source selection structure is reduced.

The position of SDCE in the source selection structure depends on the importance of software to the acquisition and the level of risk associated with software. The size of the tailored model depends on the position of SDCE in the source selection structure, and the time and people resources available. The selection of questions depends on the technical requirements associated with the acquisition; if the source selection is a downselection and the offerors are known, there may be additional risks associated with the offerors that may drive the question selection. The selection of team members must be consistent with the contents of the tailored model in order to ensure that expertise relating to all areas selected is represented on the team; it also depends on availability of team members and the conflicts of interest they may have with a particular offeror.

The levels at which SDCE results are generated may depend on the position of SDCE in the source selection structure. In general, it is recommended that SDCE results be developed at the CC level and rolled up only at the overall SDCE level, however, that may not always be possible. There are two cases where this rule is difficult to apply: first, if SDCE is distributed among several areas or factors, results may need to be developed at different levels corresponding to the areas and factors where SDCE is distributed; second, if SDCE is an Area by itself, and factors are identified under the SDCE area, the AFFARS requires that results be generated at the factor level, and the factor level may or may not correspond to CCs. For example, if there are too many CCs, the factors may correspond to groupings of CCs, and results will need to be generated for each of these groupings. Therefore, some dependency exists between the decision of how to document the SDCE results and the decisions of where to place SDCE in the source selection structure.

Finally, the decision to perform a site visit depends only on the schedule of the source selection and the duration of the discussions; it is independent of other SDCE planning decisions. Site visits should be planned, and the decision to perform them should be postponed until the last possible minute, so as not to preclude the possibility of conducting them.

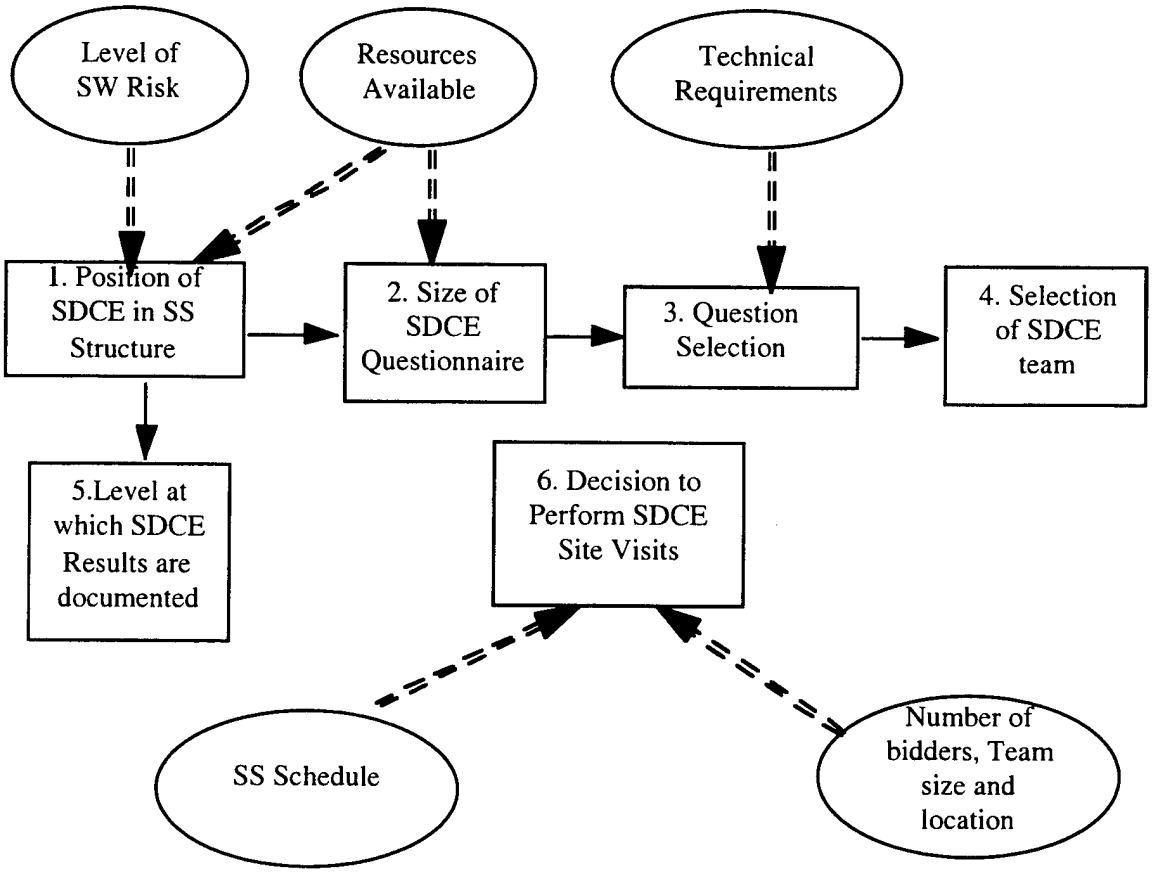


Figure 5. Dependencies Between the 6 SDCE Tailoring Decisions

5. Recommendations

The following are lessons learned collected from various people who participated in past SDCEs. They are organized by SDCE phase.

5.1 Determination of Applicability Phase

5.1.1 Decision to Perform an SDCE

If software is not a major risk factor, or if the program office does not buy in to the method, SDCE should not be performed. SPO buy-in is not always easy to achieve. We had a couple of situations where the Procurement Contracting Officer (PCO) had a hard time with two unique features of SDCE: (1) the large volume of SDCE support material sent by the offerors and (2) the site visits. Therefore, it is important to explain the SDCE process to the program office people who will be in charge of the source selection, including the Procurement Contracting Officer (PCO), and explain the SDCE-unique features and their purpose. If there is insufficient buy-in, the method should not be used.

5.2 Preparation Phase

5.2.1 SDCE Position in Source Selection Structure

The Source Selection Structure is a hierarchical structure of source selection criteria used as a uniform baseline against which each offeror's proposal is compared. It is typically defined in terms of areas and factors, or factors and subfactors (see Figure 6). By its nature, SDCE always relates to portions of the proposal (factors, subfactors) other than the SDCE portion, which makes it difficult to place SDCE in the Source Selection structure. In particular, SDCE almost always relates to the Software Technical approach, the Software Management approach, and the System Engineering approach. This does not mean SDCE needs to be distributed among all these other components. Past experience has shown that evaluating SDCE as an integral component, i.e., a separate factor or subfactor, facilitates the evaluation and enhances the value of its findings. It is important to deconflict SDCE from related portions of the RFP without damaging the integrity of the evaluation. This can be done by encouraging communication between the SDCE team and teams in charge of other related areas and factors. In general, SDCE should be placed close to related components of the source selection. By order of relevance to SDCE, software technical approach is the most relevant other portion, followed by systems engineering.

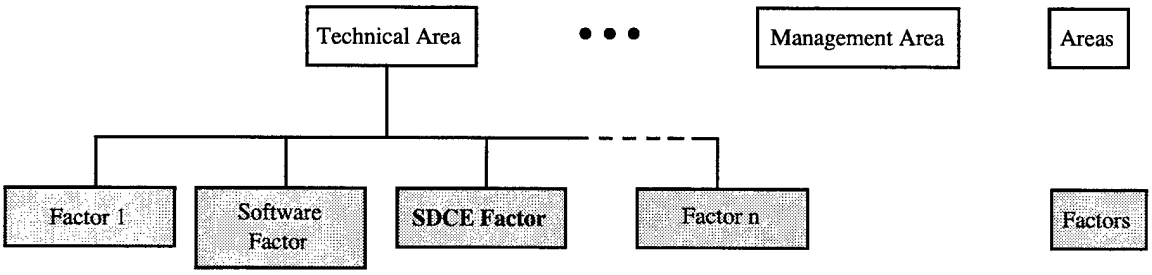


Figure 6. Example of SDCE Position in Source Selection Structure—Scheme 1

Two schemes are presented here. One scheme is based on past experience that utilized the old version of the AFFARS. A solution that has worked in the past is to have the Software Technical Approach and SDCE as two factors under the Technical Area (see figure 6). Another scheme, illustrated in figure 7, is to place SDCE in the "Performance Confidence" part of the source selection structure, if such a structure is adopted. The first scheme is based on successful past experiences, while the second scheme is derived from early versions of the AFFARS rewrite.

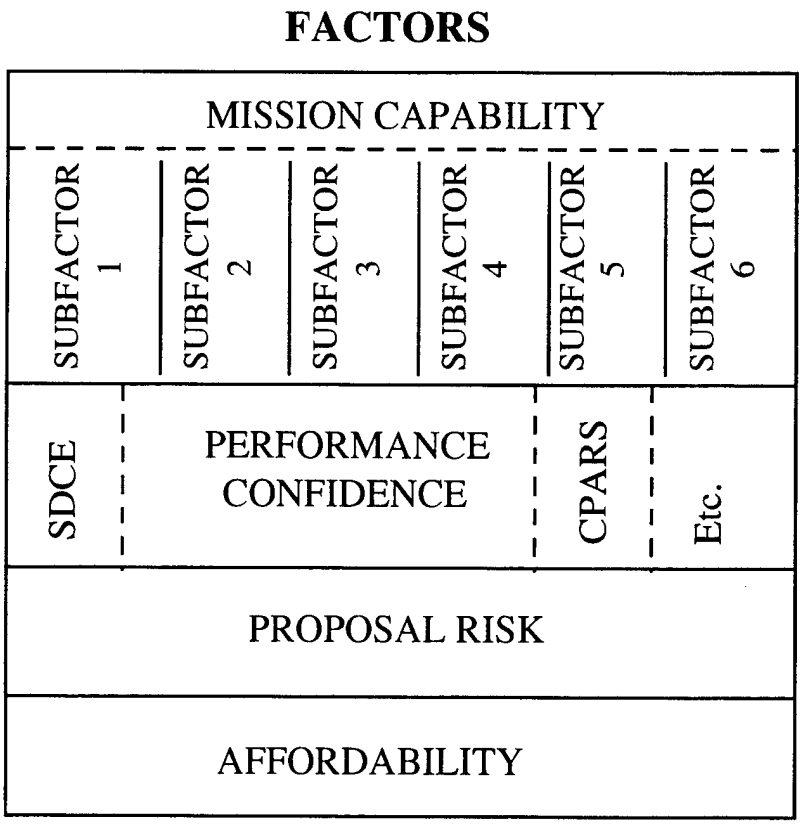


Figure 7. Example of SDCE Position in Source Selection Structure—Scheme 2

5.2.2 Model Tailoring

Model tailoring refers to the activity of taking the 717-question SDCE questionnaire, and reducing it to a small set of questions that reflect the high value discriminators for the acquisition at hand.

- *Process of selecting the SDCE questions.* The process of selecting the SDCE questions, i.e., the process used to tailor the model, offers different possibilities regarding the number of people involved in the tailoring, the use of tailoring tools, and the use of "core" questions. The more people are involved in the selection of SDCE questions, the less efficient that process becomes, and the larger the tailored model ends up being. It is therefore recommended that a small group of people (one or two) tailor the model, and then get their tailoring reviewed by a large number of people from the SPO representing each of the other areas of the RFP. This ensures buy-in from the SPO and helps keep the tailored model consistent with other portions of the RFP. There are a couple of aids available during the tailoring activities: several tailoring tools were developed at SMC, ASC and Aerospace [ref 6].

  There are 14 questions that have been identified as core questions (see chapter 6). It is recommended that the first step in the tailoring be the selection of a target number for the total size of the tailored SDCE questionnaire. As a second step, the core questions can be used as a baseline. Additional questions can then be selected, based on the technical requirements and risks associated with the acquisition, and consistently with the target for total number of SDCE questions. One way to do that is to generate a list of software risks, map the software risks to the FAs, CCAs, CCs, then select the actual questions from each CC. The final step is to review the overall set of questions to make sure dependencies between questions across the CCs are preserved.

- *Modifications to the SDCE model.* When the SDCE AFMC pamphlet was first completed, it was recognized that the model would evolve based on the fact that it represents the most common software risks, which in turn are derived from lessons learned and new technologies. Both the lessons learned and the new technologies evolve with time, and so the model needs to evolve. For purposes of consistency between different applications of the method, and to keep some control over the quality of SDCE applications, the AFMC pamphlet restricts the modifications that can be made to the model to additions or deletions only. Furthermore, before a new CCA or CC is developed for an acquisition, the AFMC SDCE OPR should be contacted to determine if CCAs or CCs similar to those needed have already been developed by some other organization. Consistently with these recommendations, Aerospace developed new sections for the technology area FA6. The Aerospace augmented SDCE model was succesfully used on several SDCEs, and is documented in [ref 7].

  When new questions and criteria are added, care should be taken to focus the questions and include as much detail as possible in them. The questions should be viewed as a tool for soliciting offeror inputs that come in the form of responses to the SDCE questions. Questions that are general may generate responses that lack the focus and detail needed to complete the assessment. It should not be assumed that details or clarifications will be obtained later, as that may not be the case: sometimes discussions are not allowed. Even when discussions are allowed, the number of clarifications requested is limited to critical areas where the existing offeror material indicates the possibility of serious problems, not areas where the government did not request the right kind of material.

5.2.3 Evaluation Standards

Evaluation standards establish the level an offeror's proposal must meet in any area, factor or subfactor to be judged acceptable ("green"). The evaluation standards associated with SDCE should be written in such a way as to capture the 3 elements of an SDCE, namely:

- Soundness of the choices of software processes, methodologies, tools and technologies for the program at hand;
- Completeness of the proposed plans and their consistency with the proposed approach;
- The existence of past experience in the proposed methods, tools and technologies, alternatively, a good justification for proposing new approaches.

Furthermore, the level of detail in the evaluation standards associated with SDCE should be consistent with the position of SDCE in the source selection structure, and their content should be consistent with the tailored model.

5.2.4 Bidders' Conference

It is recommended that SDCE be briefed to the contractors as part of the bidders' conference. This promotes early dialog with the contractors regarding their software proposal, and helps the contractors understand SDCE.

5.2.5 Instructions to Offerors

Instructions to offerors must be detailed yet clear. Four specific tips are included below:

- *Executive Summary.* In addition to responses to the SDCE questionnaire, a paragraph or two describing the organization of the offeror team, the allocation of software functions among primes and subs, and the general characteristics of the software (number of lines of code, language used, etc.) can be very helpful to the evaluators, and should not be hard to generate by the offerors. This reduces the need for evaluators to go digging in to different portions of the proposals, and minimizes the risk that the evaluators will miss some important information about the offeror's software approach.

- *Use of page limits.* Technically, no portion of the SDCE volume should be page limited, however, that is not always practical or acceptable to the program office. If limits need to be established, the following guidelines should be followed: The support material should not be page limited, because it often comes from pre-existing documents, which should not be modified for the purpose of SDCE. There are two kinds of limits that can be used: (1) the number of past project samples for a given CC can be limited, we recommend 1-2 samples/CC); and (2) the total number of pages for SDCE responses can be limited; it is recommended that the total number of pages for SDCE responses equal one page/question, and that the offerors be given the freedom to allocate the total number of allowed pages among the different questions as they see fit.

- *Software Development Plan(s).* If an SDP is not required with the proposal, it should at least be suggested as a good document to provide among the SDCE support material.

- *Templates for SDCE support material.* Several problems were experienced with the RFP templates provided in the AFMC pamphlet. In particular, the project cover sheet template contained insufficient information about the technical relevance of the project sample provided. The support material was not adequately cross-referenced to the CCs, and some of the military specifications and standards mentioned in the template headers are no longer applicable. As a result, the templates have been updated, the updated templates have been successfully used on more than five source selections; they are provided in chapter 7, and in appendix A. It is recommended that the updated RFP templates be used in lieu of those provided in the SDCE AFMC pamphlet.

The reader is referred to appendix A for an example of SDCE Instructions to Offerors that incorporates the above recommendations.

5.2.6 Training

The skills required to perform SDCEs fall into two categories: knowledge of the SDCE method and process, and knowledge of the technical subject matter. SDCE training material is available in a variety of forms: AFMC offers a three-day SDCE seminar that can be scheduled through the SDCE OPR for AFMC, and The Aerospace Institute offers a three-hour SDCE course, and a one-hour SDCE Overview. Regarding the technical skills, the criteria used to select SDCE evaluators should include technical expertise in the software subject matter, a skill that cannot be taught in a short course, and for which extensive experience is required. The only additional technical training needed is training in the technical requirements of the acquisition at hand. It is highly recommended that all members of a given SDCE team be provided with the technical requirements for the acquisition at hand prior to the start of the proposal evaluation (Operational Requirements Document, or Technical Requirements Document, or A-Specifications, etc.), and that they be encouraged to read them.

5.3 Evaluation Phase

5.3.1 Allocation of SDCE Questions to SDCE Evaluators

Allocation of SDCE questions to SDCE evaluators is typically done based on the availability of evaluators and their technical strengths. The following guidelines should be observed: each question should have at least double coverage in order to ensure that no input from the bidders was overlooked; not all evaluators need to make a full-time commitment to the SDCE team, however, it is important to have a core set of 2 to 3 people who are dedicated to the evaluation for its duration; finally, our observations are that one evaluator can review at most three CCs per day per offeror, and an allocation of two CCs per day per offeror is advised.

5.3.2 Scheduling of Evaluation Activities

The evaluation activities that need to be scheduled are the start and completion of the individual evaluations, the discussion sessions, and the writing of an SDCE report, if one is written. The purpose of the discussion sessions is to discuss the findings of the individual evaluators with the rest of the group, primarily to come up with an integrated set of results, but also to share information, especially in situations where inputs for one CC are relevant to another one, as is very often the case. It is recommended that a general discussion session be held at least once for each offeror. The duration of such a discussion depends on the size of

the tailored model. Based on past SDCEs, one-half day discussion session per offeror is sufficient for a 40-question SDCE. Developing an SDCE report is not required, however, it can be useful to capture the SDCE findings before they get integrated with the rest of the source selection findings, and generating a report is one mechanism for doing that. The report can contain a documentation of the strengths, weaknesses, and risks identified for each offeror, and any other context information, such as the composition of the offeror's team, the quality and presentation of their SDCE input, and any unique features contained in their SDCE volume.

5.3.3 Site Visits

If site visits are allowed, they should be focused on the weaknesses and the areas needing clarifications, and prioritized according to their risk levels. Contractors should be discouraged from giving open-ended presentations or demonstrations; instead, a detailed agenda should be sent by the government. The schedule for the site visit should allow one day for the site visit, half a day for analyzing the information provided during the site visit, and another half-day to verify the additional information with the contractors, for a total of two days plus travel time.

5.3.4 Evaluation Results

The process for developing source selection evaluation results is mandated by the FAR [ref 4] and the AFFARS [ref 5]. It consists of a build-up that starts with atomic elements consisting of strengths, weaknesses and risks, which are then rolled up to the subfactor or factor level and associated with symbolic ratings (e.g., proposal ratings of blue, green, yellow, red; or risk ratings of High, Medium, Low). A strong emphasis is placed in the FAR and the AFFARS on the importance of generating detailed write-ups, also known as narrative assessments, to justify every component in the roll-up process from the initial strengths, weaknesses and risks to the final symbolic ratings.

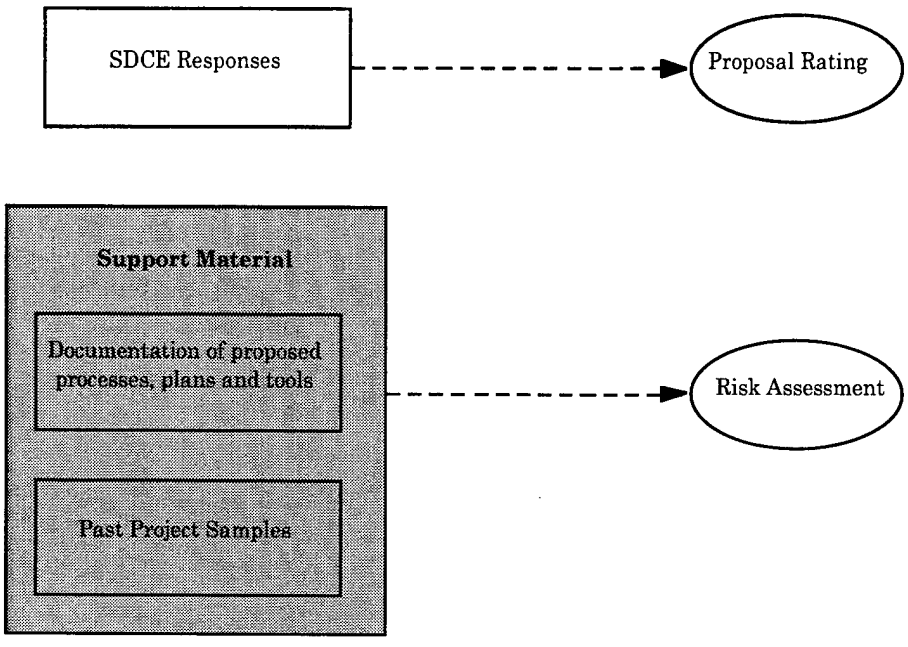


Figure 8. Suggested Mapping of SDCE Inputs to Proposal Rating Categories

There are two problems that can face SDCE evaluators in the development of SDCE results: how to decide which SDCE results constitute Weaknesses versus Risks, and how to map the templates provided in the SDCE pamphlet to the AFFARS format. Since the Strengths and Weaknesses components of the evaluation get rolled up into the adequacy rating (or "proposal rating"), which represents the adequacy and soundness of the proposed approach, and the risk components get rolled up into the Risk Rating (also known as "proposal risk"), which is an attribute of the approach corresponding to the level of risk associated with the proposed approach, it is suggested that the evaluation of questionnaire responses be used to develop the adequacy rating (proposal rating) and that the support material be used to develop the risk rating (proposal risk). This paradigm is illustrated in figure 8.

The AFMC SDCE pamphlet contains templates for developing SDCE results, however, the information in the SDCE templates is not identical to the information required by the AFFARS. In particular, the templates in the pamphlet contain a field for adequacy ratings with values of Strong, Moderate, or Weak (S, M, W), and a field for risk ratings with values of High, Medium, or Low (H, M, L). The SDCE templates also ask for comments to go along with the ratings. The AFFARS, on the other hand, asks for narrative assessments to justify the strengths, weaknesses, and risks. Furthermore, the proposal rating required in the AFFARS is a four-valued rating. The two formats need to be mapped such that the comments field in the SDCE template is used to document the narrative assessments, and the proposal rating and risk assessment in the templates are given the same number of values as defined in the applicable regulations (Air Force regulations use four valued color ratings for proposal ratings). New evaluation templates were developed for our more recent SDCE applications. They are provided in Appendix B "SDCE Evaluation Templates". AERO_SDCE is a tool that was developed to automate the management and roll-up of SDCE result documentation [ref 8].

5.4 Post-Award Phase

5.4.1 Post Award Activities.

This is by far the most neglected of all SDCE activities. One reason why the SDCE-identified risks are not followed up is that the SDCE results get lost after they have been tightly integrated with other source selection results, so it is not easy to recover the original SDCE findings after the source selection is over. This is especially true if SDCE does not get a separate set of ratings in the source selection, such as when it is distributed among different areas and factors, or when it is too low in the source selection structure. Another reason is that the source selection results, including SDCE results, are source selection sensitive, and therefore become hard to access once the source selection is over. A contributing factor is the change in personnel, which often happens with the start of a new contract. Three things can be done to help ensure post-award SDCE follow-up:

1. The SPOs should be educated about the importance of software risk in general and the importance of following up on the SDCE-identified risks in particular.

2. The transition of SDCE results outside the source selection should be planned. This is facilitated by documenting the SDCE results in a separate report and declassifying the portion of the report that addresses the successful offeror. Aero_SDCE is a tool that manages the documentation and integration of SDCE results with source selection results such that the original SDCE findings are preserved [8].

3. The RFP should include provisions for post-award SDCE follow-up. The provisions can include a post-award follow-up SDCE (see chapter 7, SDCE outside the Source Selection), and award fee criteria for SDCE.

6. Core Questions

This section provides a core set of SDCE questions and criteria. The proposed set corresponds to the questions that were most frequently asked on 9 past SDCEs for which question selection was tracked. This set is proposed only as a starting point when selecting SDCE questions for a particular tailoring, additional questions should be selected based on the program's risk profile. The reader is referred back to section 5.2.2 for model tailoring guidelines.

6.1 List of Core Questions and Criteria

The following lists 14 questions that were the most frequently used questions on the past SDCEs that were tracked.

CC 1.3.2: Subcontractor Management

*** Question 1:**

Fully describe your process for subcontractor management including reporting and control of the subcontractor software development activities. How does this process relate to and integrate with your overall system program management approach? Describe how the subcontractor management and review activities are reflected in the program level system engineering planning documents (IMP/IMS/ITAMP). **C1**

Criterion 1:

The proposed subcontractor management process is integral to the system program management process and provides integrated reporting and control of the subcontractor software development activities consistent with the program's management control system.

CC 2.1.5: Systems Requirements Management

*** Question 1:**

Describe the process used to provide two-way requirements traceability. At what point is requirements traceability established and documented? What provisions exist to maintain the traceability? **C1**

Criterion 1:

Two-way requirements traceability is maintained from system specifications to hardware and software configuration item specifications.

CC 2.6.1: Test and Integration

*** Question 4:**

Describe any special integration and test plans developed for commercial-off-the-shelf (COTS) software or other reuse software? **C4**

Criterion 4:

Any use of commercial-off-the-shelf (COTS) software or other reuse software is incorporated into system integration and test planning.

2.7.1: Reuse

*** Question 2:**

What trade-off studies have been done or are planned to evaluate the costs, benefits, and risks of the opportunities to reuse existing system and software components? **C1**

Criterion 1:

Opportunities to utilize previously developed system and software components (including architectures, designs, code, and documentation) are identified and subject to trade-off studies.

CC 3.3.1: Software Requirements

*** Question 1:**

Describe the software requirements analysis process to be applied. Identify the specific methodologies and tools to be used to support the analysis process. What organizational element is responsible to perform the analysis? Identify the input to and output product from the analysis. **C3**

Criterion 3:

The selected requirements analysis methodology is compatible with other methodologies applied on the program. The analysis methodology is supported with necessary tools.

CC 3.3.2: Software Requirements

*** Question 1:**

Describe the software development activities that result from a change in or addition to the requirements. When do they get performed? How do you ensure that they are performed? **C1**

Criterion 1:

The software development artifacts (requirements, design, code, documentation) are revised as changes to the requirements are incorporated.

CC 3.4.1: Software Design

*** Question 1:**

Describe the process and specific methodologies used to develop the top-level and detailed software design. Is the same methodology used to maintain the design through development and life cycle support? What tools are used to support the methodology? **C1**

Criterion 1:

A methodology is used to develop, document and maintain the top-level and detailed software design.

CC 3.4.1: Software Design

*** Question 3:**

What mechanism and format are used to describe the execution priorities of the different components, and the execution control? **C2**

Criterion 2:

The design description includes the (static) structure and the (dynamic) behavior of the software.

CC 3.5.2: Software Coding

*** Question 2:**

Describe your process for estimating the effect of code changes on other parts of the system, including variables and other software components. What tools are used? Who is involved in the process? **C2**

Criterion 2:

Code changes are reviewed for correctness, and to avoid undesired impact on other software and system variables and components.

CC 3.6.1: Software Test and Integration

*** Question 1:**

Describe your process for planning the software integration. How many different components do you integrate at once? How do you determine the order for integrating the different software components? Describe how your integration process accommodates all levels of software integration. **C1 C2 C4**

Criterion 1:

The software integration planning takes into account the interdependencies between the different software components and the criticality of each component.

Criterion 2:

The software integration planning takes into account the availability of other components of the system.

Criterion 4:

The software integration planning and process accommodate software integration starting with the lowest level elements, i.e., units through all levels, including CSCI and CSCI/HWCI.

CC 3.6.2: Software Testing

*** Question 2:**

What tools will be used for testing? When will they be available? Will they require any special inputs? Will their outputs require any special processing? What is your process to ensure that all required test resources have been planned and allocated? **C2**

Criterion 2:

A process exists to ensure that software testing is adequately planned with sufficient test resources.

CC 4.4.2: Metrics

*** Question 1:**

Identify the metrics you plan to collect on this program, which system or software product they apply to, which process they apply to and or what progress they measure. **C1**

Criterion 1:

The metrics selected for the program address the system and software products, the process used to generate the products, and the progress of the development effort.

CC 4.7.2: Configuration Management

*** Question 5:**

What is the program approach to establishing and controlling developmental baselines and test configurations? **C4**

Criterion 4:

Procedures exist and are followed to create and maintain developmental builds and incremental test baselines.

CC 5.7.2: S/SEE

*** Question 4:**

For each tool in the S/SEE, describe its functionality, its maturity, the quality of its documentation, and how it will be supported during the program. Explain the rationale for selecting new (not yet matured) tools and how confidence is established in the ability of these new tools to meet program needs. **C1 C2**

Criterion 1:

The S/SEE components support the program's software engineering development and management requirements, functions, methodologies, and activities.

Criterion 2:

The S/SEE components are mature and well documented. New tools are determined through systematic evaluation to meet program needs.

6.2 Process Used to Derive Core Questions

SDCE question selection was tracked on 9 programs. For each question in the 717 question model, a number was computed, the "number of selections". This number indicates how many times the question was selected. For each question, the probability for that question to be selected "number of selections" times was computed, i.e., the probability that the question is selected the number of times it was in fact selected, if the selections were made randomly; that number was called the "Random Selection probability". The complement of that probability was then computed and defined as the "Core Confidence metric". Thus the core confidence metric represents the level of confidence that a given question was not selected "number of selection" times at random. Each of the questions contained in the list of 14 had a core confidence metric higher than 99% (see figures 9 and 10).

The question selections were done independently from one program to the next, i.e., by different teams of people. How independent the question selections were from one program to another can be argued. We recognize that some teams may have been influcenced by the selections made by their collegues on previous teams, however, we feel that this influence is offset by tendencies of our colleagues to want to differentiate themselves and do better than the previous team.

The core was identified in terms of questions instead of criteria for two reasons. The first reason is that the number of questions seems to be a better metric for assessing the effort required for the contractors to respond to SDCE than the number of criteria, since the contractors generate one response per question, rather than one response per criterion, at least normally. Furthermore, our experience showed that the number of question metric tended to be scrutinized by the Source Selection Evaluation Board (SSEB), more than any other number associated with SDCE tailoring. The other reason for defining the core in terms of questions rather than criteria is that the questions constitute the main tool for soliciting information from the contractors, therefore the selection of the questions is more important than that of the criteria for obtaining the right information from the contractors. This is especially true when site visits are not held, in which case the responses to the questions become the main source of inputs for the evaluation.

- •Total # of SDCE Questions = 717
- •Average questionnaire size = 62
- •Total number of SDCEs counted = 9
- •Probability that the same question was chosen 4 times is less than .008
- •Probability that the same question was chosen 9 times is less than 10^{-9}

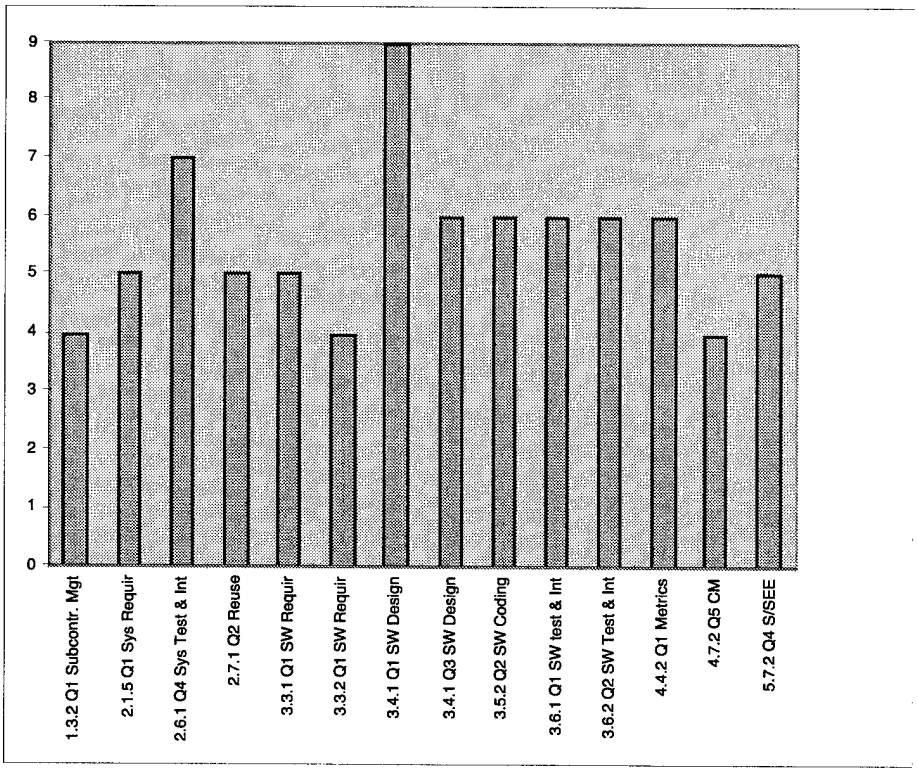


Figure 9. Core Confidence Associated with SDCE Core Questions

We define three variables:

N = the total number of SDCE questions (=700).

M = the number of programs that tailored the SDCE question set (=9).

n = the average number of SDCE questions selected by each program (=60).

If we let p equal the probability that a given question was selected at random on one of the programs using SDCE, then p can be computed as follows:

The total number of subsets of size n out of N questions is $\binom{N}{n}$.

The total number of such subsets that include the given question is $\binom{N-1}{n-1}$.

Thus,

$$p = \frac{\binom{N-1}{n-1}}{\binom{N}{n}} = \frac{n}{N} = \frac{60}{700}$$

Now we can compute the Random Selection probability, i.e., the probability that a given question was selected at random by at least k of the programs using SDCE. Using the binomial formula,

$$P_k(N,M,n) = \sum_{j=k}^{M} \binom{M}{j} p^j (1-p)^{M-j}$$

Finally, we can define the Core Confidence metric as the confidence that a given SDCE question, selected by at least k of the programs using SDCE, was not selected that many times at random. This is just

$$C_k(N,M,n) = 1 - P_k(N,M,n) = \sum_{j=0}^{k-1} \binom{M}{j} p^j (1-p)^{M-j}$$

Only those SDCE questions with a core confidence greater than 99% have been included in the core set.

Figure 10. Derivation of SDCE Core Confidence Metric

7. SDCE Outside the Source Selection

SDCE can be thought of as having two components: the model component and the process component. The model represents years of experience in software, and encodes the software risks experienced by the many authors who contributed to the material in the SDCE model. As such, it can be used for any risk assessment exercise, whether or not the exercise is conducted within the strict constraints of a source selection. The process, on the other hand, was designed to be consistent with the source selection process, as a tool for ensuring that the selected offerors have adequate software capabilities. Therefore, using SDCE in a non-source selection situation requires modifications to the SDCE process.

There have been several attempts at performing SDCE outside the strict source selection framework. These attempts have been driven by two distinct motivations corresponding to two different SDCE scenarios. The first motivation is the tight schedule of source selections in the current environment of acquisition reform, which has made it very hard to conduct site visits within the source selection schedule. In this scenario, scenario 1, some of the SDCE activities would be decoupled from the source selection to allow more time for the evaluations, but SDCE results would still be used in a source selection. The second motivation is the need to perform software risk identification after contract award: SDCE seems like a good tool, the use of which could be extended beyond source selection. In this scenario, scenario 2, SDCE results would not be used for a source selection, but simply to identify risks.

One attempt was made at an early-start scenario 1 SDCE, i.e., in a competitive environment. It amounted to starting the evaluation portion of SDCE before the official proposal receipt but after the RFP had been sent out. This was possible because the source selection was a downselection and all the offerors were known in advance. Starting the SDCE in advance of proposal receipts gave the SDCE team additional time to perform their initial evaluation. Other problems, however, were experienced, due to the fact that the proposals were not available with the SDCE volume. A portion of the SDCE evaluation had to be redone after the proposals arrived. In the end, the site visits still needed to be scheduled within the discussions timeframe, which was too short, so site visits were not held after all. It is recommended that when SDCE is performed in support of a source selection, it be performed in accordance with the process described in the pamphlet, augmented with the guidelines provided here, and that scenario 1 not be repeated.

Two post-award scenario 2 SDCEs were contemplated, both were postponed and have not yet been rescheduled. There are two difficulties associated with performing post-award SDCEs. The first difficulty is that the contractors have no incentive to perform an SDCE if they do not stand to gain from performing one (or lose from not performing one). The incentive is clear in source selection, however after contract award, unless an award fee is tied to SDCE and spelled out in the contract, the incentive is not as strong. The second difficulty stems from the fact that contractors' efforts for preparing for an SDCE performed during source selection are reimbursed with Bid and Proposal (B&P) funds, whereas when SDCE is performed after contract award or as part of an ongoing contract, the cost to the contractors is paid for by contract money.

If a methodology is needed for post-award risk identification activities, SDCE questions and criteria can be used, but the process should be modified. In particular, the following 3 items need to be carefully planned:

1. Timing of the Evaluation. When SDCE is performed after award, there are more options for when to conduct the assessment. It is recommended that the evaluation be schedulded at some point in the program schedule when some program artifacts have

been generated but before it becomes too late to make changes to the software, for example right before the completion of preliminary design.

2. Program Artifacts. The process should be tailored to take advantage of the fact that after contract award, artifacts exist from the contract at hand, so the evaluated material should not be limited to past project data and proposal data. In particular, the contractors should be requested to submit documentation from their program in support of the SDCE questions selected.

3. Government / Contractor Information Exchange. The Source Selection regulates information exchanges, discussions and dialogs between the government and the contractors during a source selection, as a result, they are highly formalized and minimized. Information exchanges are an important component of the fact finding used by SDCE to identify risk. The following guidelines are recommended in order to reduce the formalism associated with the fact finding, reduce the effort required from the contractors, and increase information content.

- The tailored SDCE questions should be sent to the contractors in advance, however, the contractor responses can be provided less formally than as written responses that are mailed in advance of the evaluation. In particular, the responses can be provided at the same time as the site visit is held, in the form of a presentation, with each question being addressed on a separate chart.

- The results of the evaluation should be discussed with the contractors as soon as possible in a cooperative contractor / government setting, consistent with the Integrated Product Team philosophy.

- Although contractor / government dialogs should be encouraged, they should be bounded in schedule and focused on the evaluation results, as opposed to the selection of questions. Discussions regarding question selection can go on forever; furthermore, they risk delaying or cancelling the actual evaluation.

8. Suggested Modifications to AFMC Pamphlet

The following is an enumeration of recommended additions and modifications to the AFMC SDCE pamphlet. The changes reflect the guideines and lessons learned discussed in the previous chapters.

- Changes to the SDCE Process

  Only one change is recommended to the SDCE process, namely the timing of the SDCE team selection. The sequencing of activities as described in the pamphlet indicates that the selection of SDCE team members should be performed before the tailoring of the model. As mentioned in Chapter 4, the SDCE team can be thought of in terms of two subteams: the subteam that plans the evaluation and the subteam that performs the evaluation. Although the two subteams should have some overlap in personnel, they do not have to comprise the same people, nor do they have to be determined at the same time. In fact, it is very difficult to finalize the composition of the evaluator subteam too much in advance of the actual start of the evaluations. As the RFP release date slips (which often happens) so does the source selection schedule, and with it the availability of the potential evaluators. It is recommended that the selection of the planning subteam be accomplished before the tailoring of SDCE, and that the selection of the evaluator subteam be started after the tailoring of the model and completed soon after RFP release. This would allow the SDCE evaluators to know the schedule they are committing to before finalizing their commitment.

- Additions to SDCE Model

  An updated version of the SDCE model has been used on several SMC acquisitions. The new model has additions to FA6 reflecting new software technology trends, and additions in the areas of reuse and software architecture to support the increasing emphasis on open system architectures and reuse [ref 7].

- Improved RFP Templates

  A new template was developed for the offerors to list all substantiating documents submitted, and cross-reference them to the applicable SDCE sections. The Capability Definition Matrix was modified to delete references to specific military specifications and standards. Finally the Capability Implementation Matrix needs to be modified to disallow the use of "I" for capability Implemented but no sample provided, and to delete references to specific military standards. Appendix A "Example SDCE Instructions to Offerors" contains updated versions of the SDCE RFP templates.

- Improved Evaluation Templates

  Evaluation templates were provided in volume 2 of the SDCE pamphlet as an example of templates that could be helpful. It is recommended that the format of the evaluation templates contained in the pamphlet be aligned with the format of the source seleciton results as described in chapter 5. It is also recommended that the extensive roll-up scheme they imply be abandoned, and that SDCE results be developed at the CCA level, then rolled up to the overall SDCE level, as discussed in in chapter 4 in "Levels at which SDCE results are developed." Appendix B "SDCE Evaluation Templates" contains updated versions of the SDCE evaluation templates.

9. References

[1] "Acquisition - Software Development Capability Evaluation," Air Force Materiel Command, AFMC Pamphlet 63-103, Volumes 1 and 2, 15 June 1994.

[2] "Acquisition Management, Software Development Capability/Capacity Review," Aeronautical Systems Center, ASC Pamphlet 800-5, 11 September 1992.

[3] Paulk, M., B. Curtis, M. Chrissis, and C. Weber, "Capability Maturity Model for Software (version 1.1)," CMU/SEI-93-TR-024, 1993.

[4] Federal Acquisition Regulation (FAR), 1990 edition.

[5] Air Force Federal Acquisition Regulation Supplement (AFFARS), 1 May 1996.

[6] Haddad, R., S. Lee, and D. Nunez, "A Tailoring Tool for SDCE (SMARTT User's Guide)," TOR-95(5917)-4, The Aerospace Corp., September 1995.

[7] Haddad, R., "Revised and Augmented SDCE Model," TR-98(8550)-1, The Aerospace Corp., March 1998.

[8] Haddad, R., and T. Lang, "A Tool for Managing SDCE Results," Aerospace Technical Memorandum ATM-97(8550-04)-1, The Aerospace Corp., September 1997.

Appendix A: Sample SDCE Instructions to Offerors

Software Development Capability Evaluation (SDCE) RFP Instructions

The following information in direct support of the SDCE shall be submitted with the proposal.

1. Questionnaire Responses

In Volume VI, the Offeror shall provide responses to the questions that are included in this attachment. To reduce the SDCE preparation effort and duplication, responses to the questions may be provided directly in the documentation accompanying the proposal, such as the Integrated Master Plan (IMP), Integrated Master Schedule (IMS), or other proposal volumes. When responses to the SDCE questions are provided in other proposal information, specific page number and paragraph references shall be provided with the response to the question. Information shall be provided for the Offeror, any team member, or subcontractor who will have a role in the software development effort. Common processes require only one response. NOTE: the term "process" in the SDCE context includes procedures, standards, methodologies, tools, etc.

2. Substantiating Documents

Substantiating documents shall be submitted for all planned processes, whether employed by the prime Offeror, subcontractors, or other team members. Substantiating documents are intended to demonstrate institutionalization of proposed processes. These documents shall include:

a. Copies of corporate software-related process descriptions that are to be used in the XYZ program.

b. Copies of documents that provide evidence of current or prior use of the proposed processes. Specific page number and paragraph references for each substantiating document shall be provided with the response to each question.

3. SDCE Forms

The following forms shall be completed and submitted with the proposal:

a. List of substantiating documents.

b. Cover Sheet for each substantiating document submitted.

c. Capability Definition Matrix (one per Critical Capability Area),

d. Capability Implementation Matrix (one per Critical Capability Area), and

4. SDCE Detailed Responses

The Offeror shall supply information as described below:

4.1 Overview of the Proposed Software Development Effort

The Offeror shall provide an overview, not to exceed four (4) pages, that addresses the total software development effort, the organization of the Offeror team, and the task and responsibility distribution among the team members for the entire life cycle of the project; and the processes used to manage and control team member performance. The purpose of this overview is to provide a foundation for review of the SDCE questionnaire responses. All information in this overview shall be consistent with information provided in the Offeror's planning documentation for the program, and shall reference such information where appropriate. The Overview is included in the overall page limit.

4.2 SDCE Questionnaire Responses

4.2.1 General Information

Responses to the questions shall be concise and unambiguous. Common processes require only one response. If processes are partially but not fully common, or if different processes are used by the Offeror and any team members or subcontractors, these differences shall be identified and each process described.

4.2.2 Response Page Limits and Organization

The following instructions shall be applied in preparing responses:

a. The total number of pages permitted for the SDCE reponses to all CCs combined shall not exceed the number of SDCE questions (give a specific number). Note that the number of pages allocated for any given response is left up to the Offeror.

b. Substantiating information referenced in the responses is not subject to the page limit. Specific volume, page, and paragraph numbers are required to be supplied in the reference. References shall be made only to documents delivered as part of the proposal.

c. Past project samples shall be limited to (1 or) 2 samples per CC.

4.2.3 Substantiating Documents

4.2.3.1 Types of Documents

Substantiating documents are included in Vol VII and are intended to demonstrate experience with and commitment to the proposed processes. Substantiating documents shall be submitted for each critical capability (CC) response. These documents shall cover all planned processes, whether employed by the prime contractor, subcontractors, or other team members. Where common processes are planned, evidence of use by all relevant parties (i.e., prime contractor, subcontractors, and other team members) shall be supplied. Samples of existing processes shall be relevant to the XYZ program's needs and relate to an SDCE question (see Figures 3a and 3b, Capability Definition Matrix). These documents shall include:

a. Process Descriptions and Plans for Use—Copies of corporate software-related process descriptions that are relevant to XYZ PROGRAM. If different processes are to be employed by subcontractors and/or team members, these shall be supplied as well.

b. Project Samples—Copies of documents that provide evidence of actual use of the proposed processes (e.g., current or historical development schedules, software development plans, software requirements specifications, test and integration plans, procedures, etc.). Past project samples shall be limited to (1 or) 2 samples per CC.

c. New Process Rationale—For new processes not yet implemented, describe the benefits and risks of using the new processes and the rationale for employing them in lieu of providing examples of past application.

See Figure 1 for examples of substantiating documents.

5. Capability Cross-Reference Forms and Sample Data Cover Sheet

The forms listed below shall be completed and submitted with the SDCE responses and substantiating information. Figures 2a, 3a, 4a and 5a contain blank copies of these forms and figures 2b, 3b, 4b and 5b contain examples of each.

a. Cover Sheets for substantiating documents (one for each document submitted); see Figures 2a and 2b.

b. Capability Definition Matrix (one per Critical Capability Area (CCA)); see Figures 3a and 3b.

c. Capability Implementation Matrix (one per CCA); see Figures 4a and 4b.

d. A list of all Substantiating Documents must be provided. The list must contain document title, its unique ID and the Critical Capability (CC) that it addresses. The list of Substantiating Documents shall be organized either by ID number or by CC (see Figures 5a and 5b below).

PROJECT SAMPLE DOCUMENT	CCA/CC
Software development plans	3.1, 5.7
Program organizational charts	1.1.1, 1.1.2
Organizational charts from program manager through working-level software engineers	1.1.1, 1.1.2
Contract work breakdown structures covering software development	1.2.2, 3.1.2
Software work packages	1.2.3
Cost/schedule control system criteria reports applied to software	1.2.3, 1.2.4
Cost performance reports applied to software	1.2.3
Systems through detailed software development schedules	1.2.3, 1.2.4
Systems engineering master schedules showing software events and completion criteria	1.2.4
Subcontractor RFPs and SOWs defining software tasks	1.3
Maintenance contracts for providing software rights for post deployment	1.4
Risk management plans covering software	1.5, 3.2
Systems and subsystem specifications	2.1
Tradeoff study reports addressing software	2.1.5, 1.5.2
Requirements traceability matrices/tables	2.1.4, 2.1.5
Design review minutes	2.2, 2.3
Interface control specifications/documents	2.1.1
Systems engineering master plans	2.5.3
Systems engineering staffing plans/final reports	2.5.4
Test and integration plans	2.6.1, 2.6.2
Reuse plans covering software	2.7
Reuse trade-off reports	2.7
Software size, effort, schedule, and cost estimates	3.1.1
Past actual productivity rates	3.1.1
Software tree structures (CSCIs through units)	4.7
Software status reports	3.2.2
Software requirements specifications	3.3.1
Software development folders/files	3.4.1, 4.7
Peer review minutes/reports	3.5.1, 4.5.2
Software integration and test plans, Software Test Procedures	3.6
Software quality assurance plans	4.1.1
Software discrepancy reports	4.1.3
Defect prevention plans	4.3.1
Software development metrics	4.4
Peer review plans	4.5.1
Internal independent verification and validation plans	4.6.1
Software configuration management plans	4.7.1
Software development, integration, and test facilities plans	5.2
Software training plans	5.3.1
Software staffing plans, including actual staffing profiles on completed programs	5.4.1
Software process improvement plans	5.6.1
Integrated Master Plans, Integrated Master Schedules	1.2, 3.1, 3.2
Internal standards and procedures documents (for software development, quality assurance, configuration management, systems engineering, etc.)	3.5, 4.1, 4.7, 4.8

Figure A-1a. Examples of Substantiating Documents

Document ID	Document Title	Applicable CC(s)

Figure A-2a. List of Substantiating Documents

Document ID	Document Title	Applicable CC(s)
LM_1	F-22 Schedule Volatility Metrics	4.4.1
LM_2	F-22 SDP	3.1.4
LM_3	GPS SDP	3.1.4
•	•	•
•	•	•
•	•	•
etc.	etc.	etc.

Figure A-2b. Example List of Substantiating Documents

Cover Sheet for Substantiating Document	
Contractor:	**Sample ID:**
Sample Project Name and unique ID:	
Sample Project Customer:	
Critical Capability(ies):	
Title of Sample:	
Explain why your experience on the sample project is relevant to the proposed project.	

ATTRIBUTES	PROPOSED PROJECT	SAMPLE PROJECT
Application Domain		
Product Type		
Acquisition Phase[1]		
Software Development Phase(s)		
Award Date		
Contract Duration		
Current Project Phase/ Contract Month[2]		
Prime/Subcontractors[3]		
Software KSLOC[4]		
Language(s) and Percentages		
Target Processor(s)/OS(s)		
Applicable Standards		

[1]For "Proposed Project," phase(s) in which Critical Capability(ies) are to be used; for "Sample Project," phase in which sample was generated.

[2]Phase/month of the Sample Project as of the current date.

[3]Contractors developing the software products specified in the "Product Type" row

[4]Total number of KSLOC for software specified in the "Product Type" row

Figure A-3a. Substantiating Document Cover Sheet

Cover Sheet for Substantiating Document	
Contractor: Team A	**Sample ID:** ID X_{abc}
Sample Project Name and unique ID: Project X Design Complexity Metrics	
Sample Project Customer: U.S. Air Force Space and Missile Systems Center	
Critical Capability(ies): 4.4.2 Metrics Application	
Title of Sample: Project X Software Development Metrics Reports	
Explain why your experience on the sample project is relevant to the proposed project. Object-oriented methods and metrics were used on the sample project. The same object-oriented methods and metrics are planned for use on the proposed project.	

ATTRIBUTES	PROPOSED PROJECT	SAMPLE PROJECT
Application Domain	Weather Satellite	Communications Satellite
Product Type	Ground System (Command and Control)	Ground System (Command and Control)
Acquisition Phase[1]	EMD	EMD
Software Development Phase(s)	Design; Coding and Unit Test	Coding and Unit Test, Increments 1 and 2
Award Date		1/94
Contract Duration	8 Years	5 Years
Current Project Phase/ Contract Month[2]		EMD: Between System PDR and System CDR/Month 24
Prime/Subcontractors[3]	2 Software Subs	Prime & 1 Software Sub
Software KSLOC[4]	750	500
Language(s) and Percentages	Ada 95: 90% C++: 10%	FORTRAN 77: 75% C++: 25 %
Target Processor(s)/OS(s)	RISC 6000/UNIX	VAX 6200/VMS 6.2
Applicable Standards	IEEE 1498	DoD-STD-2167A & 2168

[1]For "Proposed Project," phase(s) in which Critical Capability(ies) are to be used; for "Sample Project," phase in which sample was generated.

[2]Phase/month of the Sample Project as of the current date.

[3]Contractors developing the software products specified in the "Product Type" row

[4]Total number of KSLOC for software specified in the "Product Type" row

Figure A-3b. Example Substantiating Document Cover Sheet

CAPABILITY DEFINITION MATRIX	REFERENCE DOCUMENTS		LOCATION OF CAPABILITY DESCRIPTION WITHIN REFERENCE DOCUMENTS
FA: _____ **CCA:** _____ **CRITICAL CAPABILITIES:**	**PROPOSED PROJECT DOCUMENT (SDP, IMP, etc.)**	**COMPANY DOCUMENT (Company Guidelines, Standard, etc.)**	**INSTRUCTIONS** • List the name/title of each reference document. • State the location of the capability description within the document by specific volume, page, and paragraph number.

Place an "X" in every column that applies

Page_____ of _____Pages

Figure A-4a. Capability Definition Matrix

CAPABILITY DEFINITION MATRIX	**REFERENCE DOCUMENTS**		**LOCATION OF CAPABILITY DESCRIPTION WITHIN REFERENCE DOCUMENTS**
FA: 2. Systems Engineering **CCA:** 2.2 Computer System Architecture Design **CRITICAL CAPABILITIES :**	**PROPOSED PROJECT DOCUMENT (SDP, IMP, etc.)**	**COMPANY DOCUMENT (Company Guidelines, Standard, etc.)**	**INSTRUCTIONS** • List the name/title of each reference document. • State the location of the capability description within the document by specific volume, page, and paragraph number.
2.2.1 Architecture Definition	X		SDP p. 50; IMP p. 24; IMS p. 13; Proposal Response,vol. IV, p. 5, para. 4
2.2.2 Adequacy of Architecture Design		X	Software Architecture Standard, Technical Report xyz, pp. 19-24.

Place an "X" in every column that applies

Page_____ of _____Pages

Figure A-4b. Example Capability Definition Matrix

CAPABILITY IMPLEMENTATION MATRIX		PROJECTS IMPLEMENTED ON										
FA CCA CRITICAL CAPABILITIES	NEW CAPABILITY											

S_{idn} — Implemented and Sample Provided, where "idn" is the unique identifier for that sample
N — New Capability (use in "New Capability" column only)

Figure A-5a. Capability Implementation Matrix

Page_____ of _____Pages

CAPABILITY IMPLEMENTATION MATRIX		PROJECTS IMPLEMENTED ON										
FA 2. Systems Engineering **CCA** 2.1 System Requirements Development, Management and Control **CRITICAL CAPABILITIES**	NEW CAPABILITY	Air Force Satellite Control Network Traffic Switch Control System	Global Positioning System IIF Control Segment	MILSTAR Automated Communications Management System	Titan IV Flight Control Subsystem							
2.1.1 Development and Allocation of Requirements		S_{id1}			S_{id2}							
2.1.2 Adequacy of Requirements		S_{id3}		S_{id4}	S_{id5}							
2.1.3 Requirements Change Control			S_{id6}		S_{idx}							

N — New Capability (use in "New Capability" column only)
S_{idn} — Implemented and Sample Provided, where "idn" is the unique identifier for that sample

Page_____ of _____Pages

Figure A-5b. Example Capability Implementation Matrix

Appendix B: SDCE Evaluation Templates

CCA SCORE SHEET

OFFEROR

CRITICAL CAPABILITY AREA

Capability Assessment

Risk Assessment

Narrative Write-Ups For CCA
(Strengths, Weaknesses, and Risks)

Figure B-1. Revised CCA Score Sheet

SDCE SCORE SHEET

OFFEROR	CAPABILITY ASSESSMENT	RISK ASSESSMENT	Strengths, Weaknesses, Risk Summaries
CCA	Strong - S Acceptable - A Weak - W	H - High M - Moderate L - Low	
SDCE OVERALL SCORE			

Figure B-2. Revised SDCE Score Sheet

Appendix C: List of Past SDCEs

The table below lists the past 12 SDCEs that were tracked and used to derive the guidelines contained in this document. For each SDCE application, the table lists the contract name, the associated program, and the general time frame during which SDCE was performed. All but one of the applications below were associated with source selections. In one case, SDCE was used to evaluate a contractor that was being considered for a sole source contract. Data from that application was used only for developing recommendations relating to model tailoring.

Contract Name	Program Name	SDCE Evaluation Date
Small Tactical Terminal (STT)	Defense Meteorological Satellite Program (DMSP)	FY94
Advanced Communication Management System (ACMS)	Milstar	FY94
Cloud Depiction and Forecasting System (CDFS) II	Defense Meteorological Satellite Program (DMSP)	FY94
Operation Control System (OCS) support	Global Positioning Satellites (GPS)	FY95
Range Standardization and Automation (RSA) Phase II	Air Force Satellite Control Network (AFSCN)	FY95
Network Operation Upgrade Contract (NOUC)	Air Force Satellite Control Network (AFSCN)	FY95
Range Communication Data Contract (RCDC)	Air Force Satellite Control Network (AFSCN)	FY95
AFSCN Command and Control Sustainment Contract (CCSC)	Air Force Satellite Control Network (AFSCN)	FY95
SBIRS High downselect	Space Based Infra Red Sensors (SBIRS)	FY96
GPS Block IIF	Global Positioning Satellites (GPS)	FY96
Classified Contract	Classified NRO program	FY96
Low Cost Contract Vehicle (LCCV) EELV downselect	Expendable Evolving Launch Vehicle (EELV)	FY97
Global Broadcasting Services (GBS)	Milstar	FY97

Appendix D: List Of Acronyms

AFFARS	Air Force Federal Acquisition Regulation Supplement
AFMC	Air Force Materiel Command
ASC	Aeronautical Systems Center
ASP	Acquisition Strategy Panel
CC	Critical Capability
CCA	Critical Capability Area
CMM	Capability Maturity Model
CR	Clarification Request
DR	Deficiency Report
ESC	Electronic Systems Center
FA	Functional Area
FAR	Federal Acquisition Regulation
OPR	Office of Prime Responsibility
RFP	Request For Proposals
SDCCR	Software Development Capability Capacity Review
SDCE	Software Development Capability Evaluation
SEI	Software Engineering Institute
SMC	Space and Missile Systems Center
SOO	Statement Of Objectives
SS	Source Selection
SSEB	Source Selection Evaluation Board
TRD	Technical Requirements Document